Flight Physics in Poland potential and perspectives

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Contributors:
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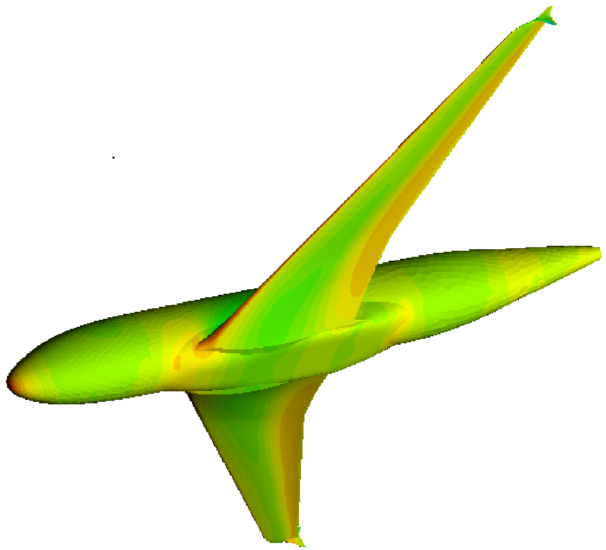



GDAŃSK
IMP-PAN
POZNAŃ
PP
WARSZAWA
ILOT+PW+WAT+IPPT
ŁÓDŹ
WROCŁAW
CZĘSTOCHOWA
PCz
GLIWICE
RZESZÓW

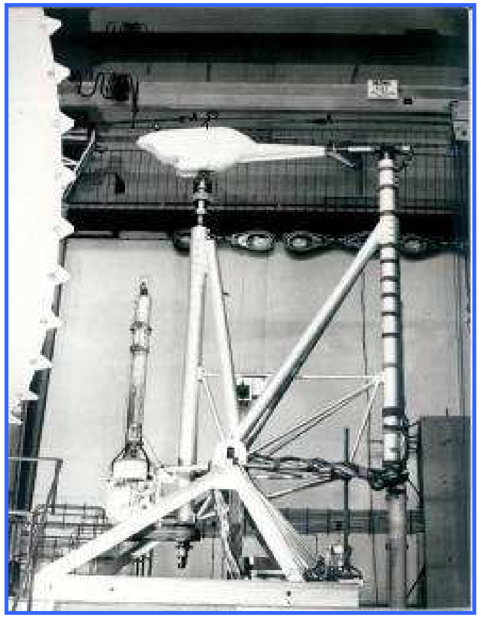
INSTYTUT LOTNICTWA

INSTITUTE OF AVIATION

WIND TUNNELS

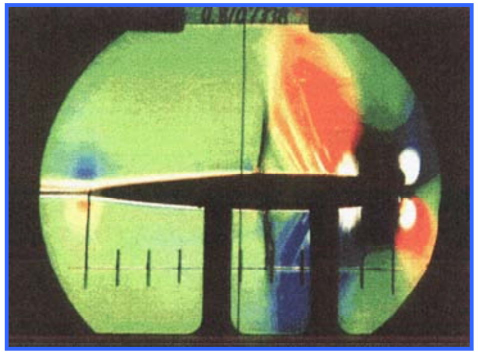
1.5 m Low Speed Wind Tunnel

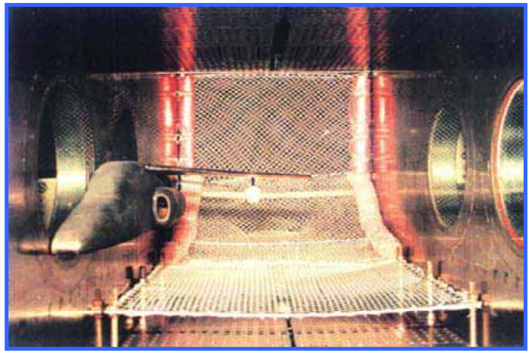
Commercial Contracts
National Grants
Helix Project



5m Low Speed Wind Tunnel

Commercial Contracts
National Grants
CESAR Project





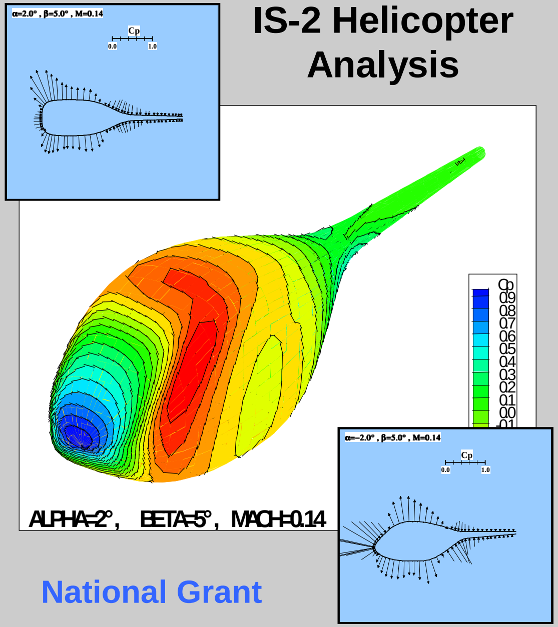
Trisonic Wind Tunnel

Commercial Contracts
National Grants
UFAST Project
CESAR Project

CFD ACTIVITES

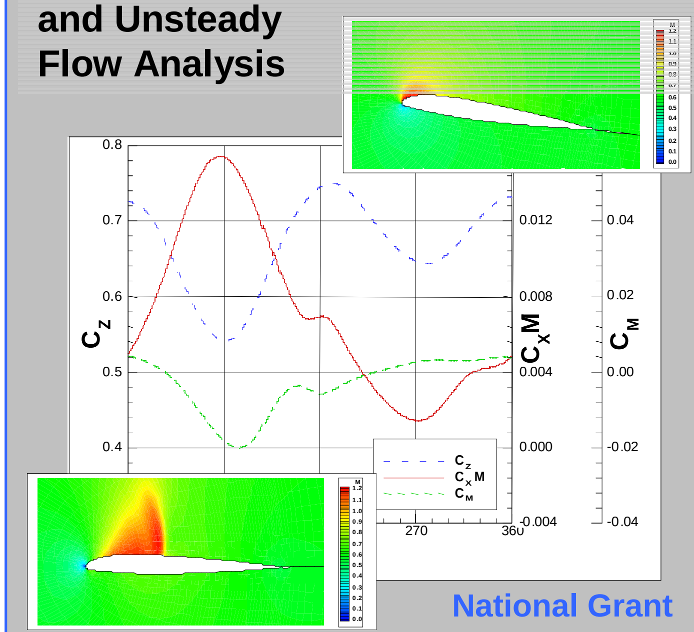
IN HOUSE SOFTWARE SIMULATION

IS-2 Helicopter Analysis



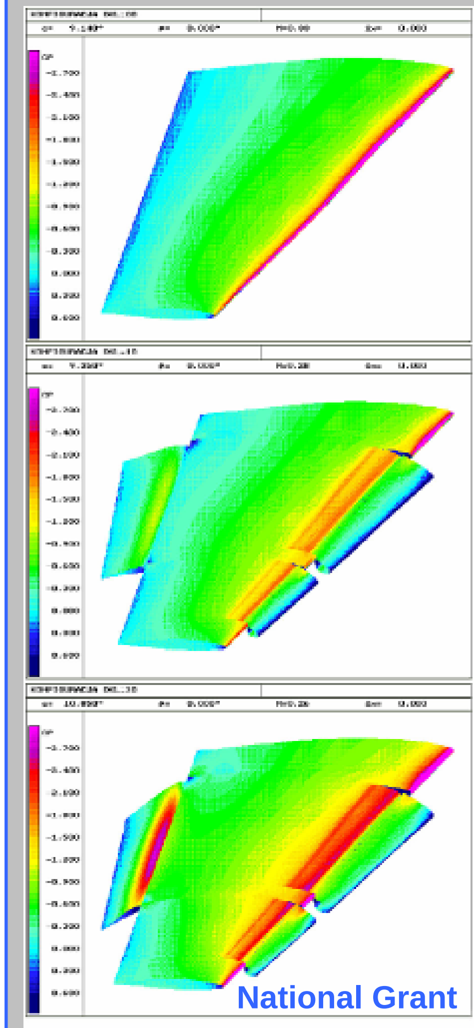
National Grant

Optimization using Genetic Algorithm and Unsteady Flow Analysis



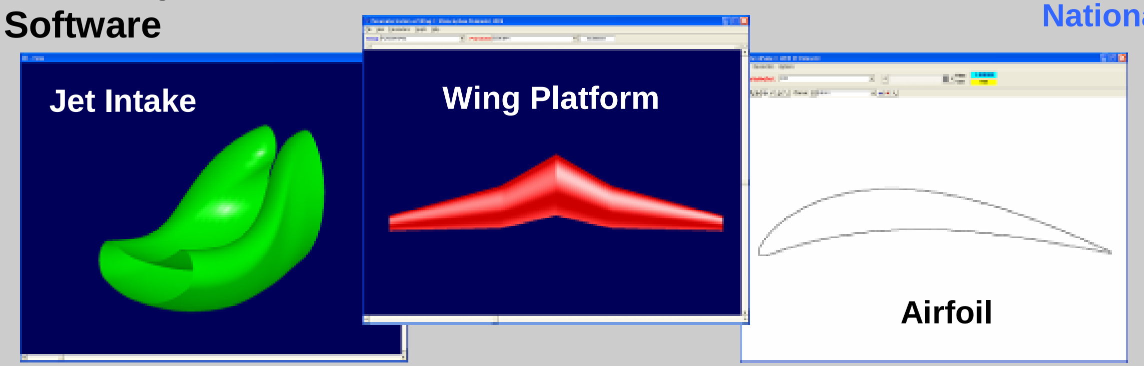
National Grant

High Lift Devices Analysis



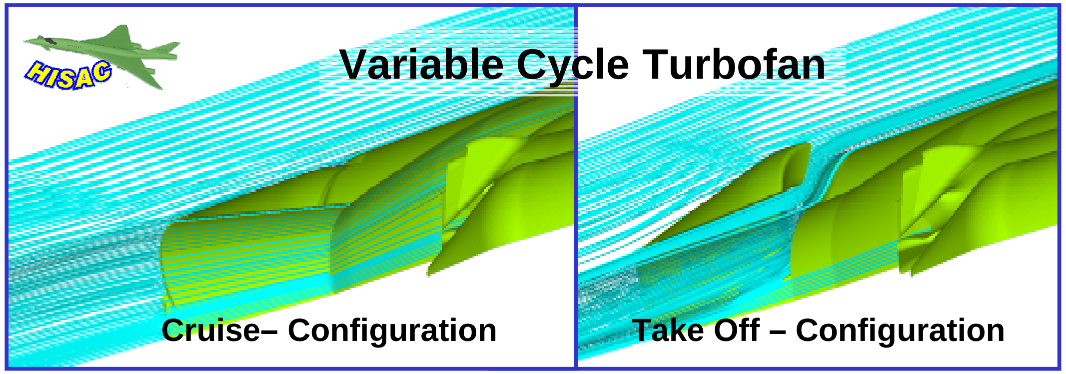
National Grant

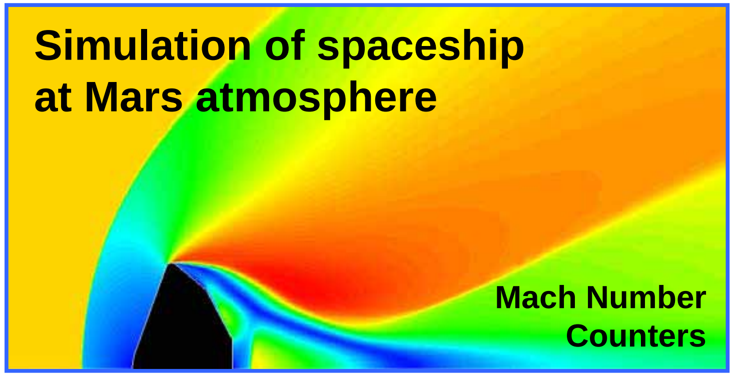
Geometry Parameterization Software

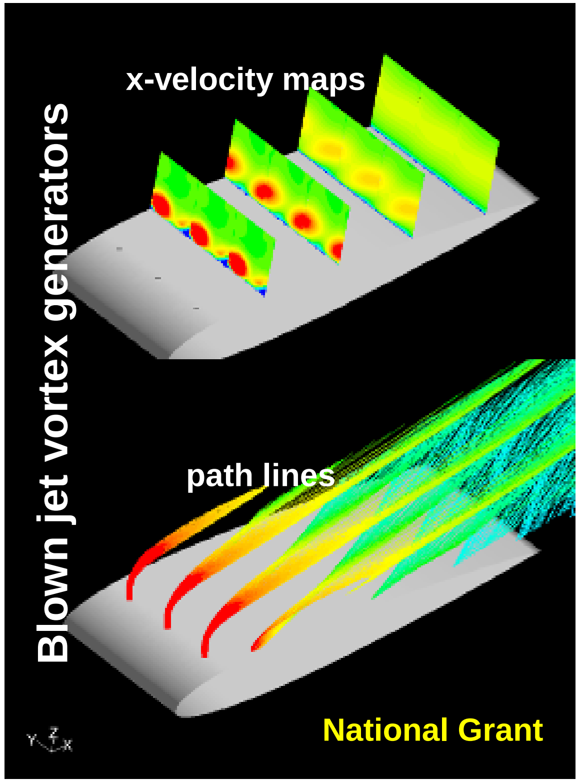


Commercial Contracts
National Grants
CESAR
NACRE
HELIX

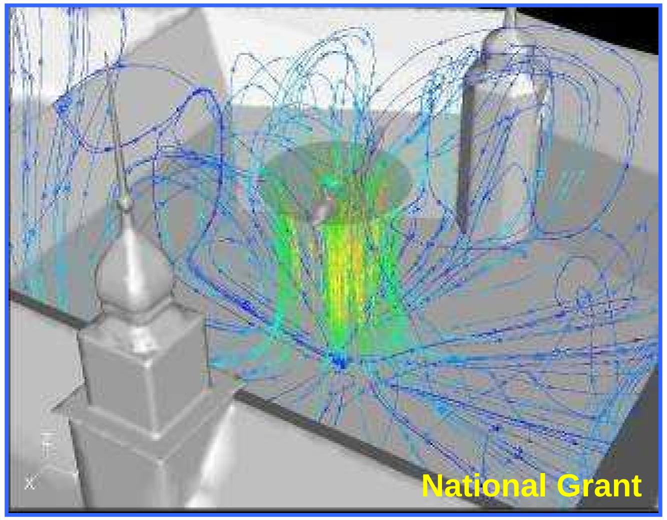
CFD ACTIVITES

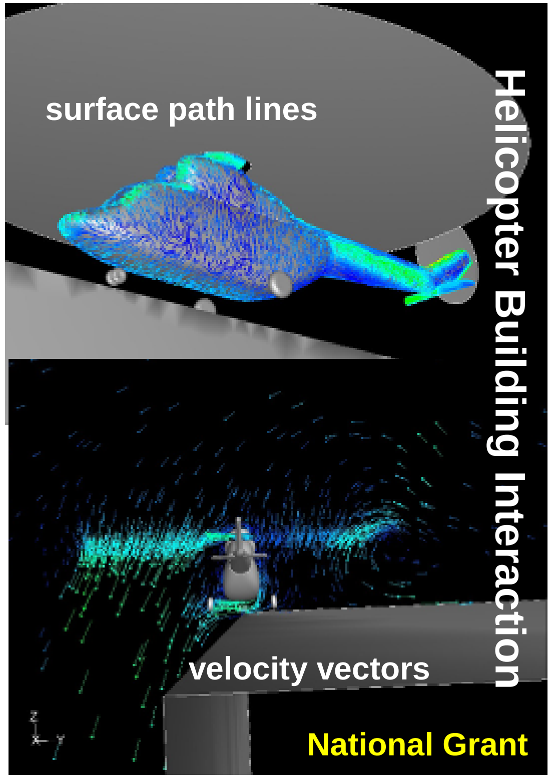






FLUENT SYMULATION





ACTIVITY
IN EUROPEAN FRAMEWORK PROGRAMS

EC Research Projects in the 5th FP

UAVNET is a thematic network to advance the development of UAVs (Unmanned Air Vehicles) for civilian purposes.

Civilian Unmanned Air Vehicles
NAS – UAV NET Thematic Network

Innovative Aerodynamic
High Lift Concepts - HELIX

HIRETT
High Reynolds Number Tools and Techniques for Civil Transport Aircraft Design

High Reynolds Number Tools and
Techniques for Civil Transport
Aircraft Design NAS HiReTT

TAURUS

Technology Development
for Aeroelastic Simulations
on Unstructured Grids

EC Research Projects in the 6th FP

Sixth Framework Programme

Environmentally Friendly
High Speed Aircraft

Unsteady Effects in Shock Wave
Induced Separation

Cost-Effective Small Aircraf

CESAR

EC Research Projects in the 7th FP

SEVENTH FRAMEWORK PROGRAMME

AEROFAST Aerocapture for Future Space Transportation
coordinator ASTRIUM-ST SAS, France

Institute of Fluid Machinery

Instytut Maszyn Przepływowych
Polskiej Akademii Nauk, Gdańsk

IMP contribution to flight physics

CFD tools:

Codes:

SPARC - In-house code

Fine-Turbo of Numeca from Brussels

FLUENT

FLOWer – aerodynamic code from DLR

Hardware:

Internal: PC-cluster, 32 CPU, 34 GB RAM

External: 1) 256× Itanium-2 Intel Dual-core,

2) >5500 cores Intel Quad, 50 TF

Experiment:

Intermittent, in-flow ambient, driven by vacuum

Pressure measurements – transducers, PSP

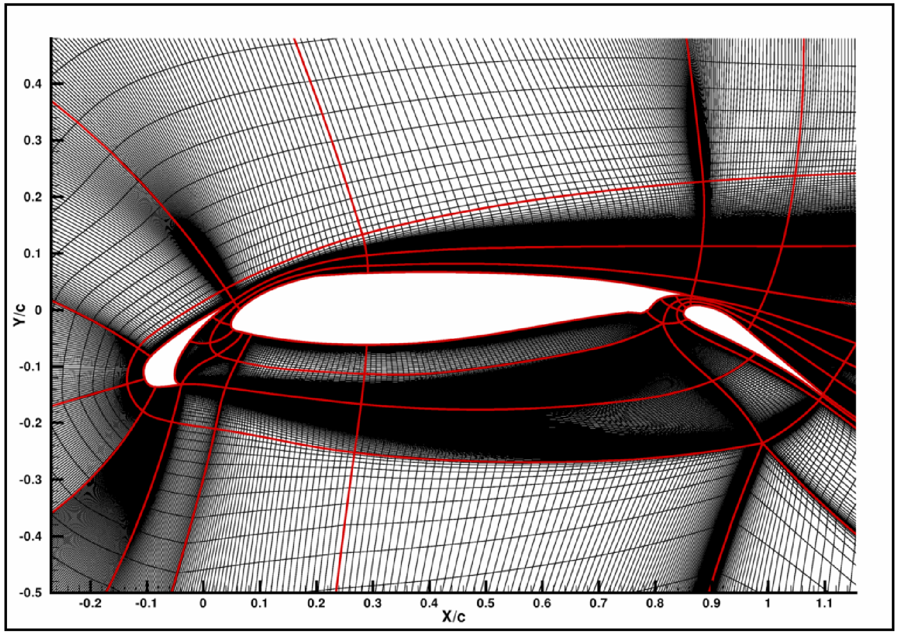
Optical systems (Schlieren, Mach-Zehnder interferometer)

20 sec. measurement time by 100x100 throat

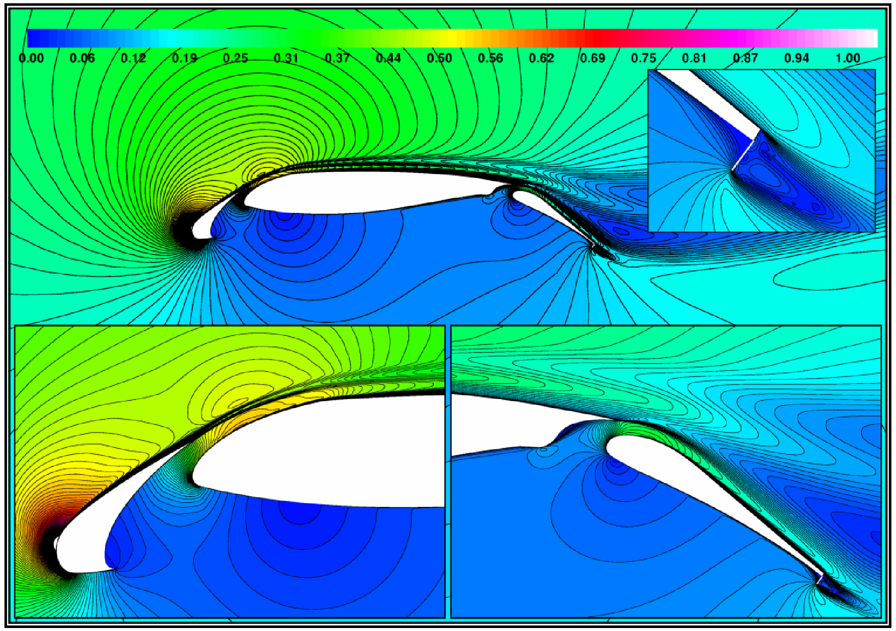
HELIX (2001-2005) *Innovative Aerodynamic High-lift Concepts*

- 5th Framework Programme, 4.4 mEUR, 15 academic and industrial partners (Airbus UK, QinetiQ UK, ILot PL, …)

  - **IMP PAN**: subcontractor of Institute of Aviation (Warsaw, PL) - SESF (Segmented Extension Slotted Flap), SFFC (Single-slotted Flap with Flow Control), LET (Lift Enhancing Tabs)



high-lift configuration – grid details

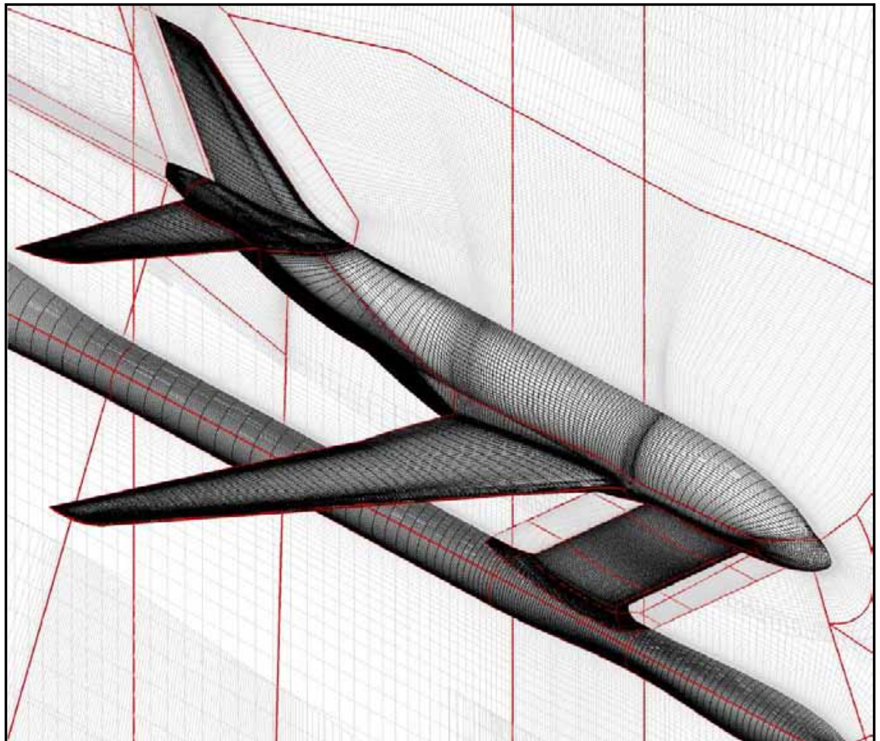


multielement airfoil with Lift Enhancing Tab

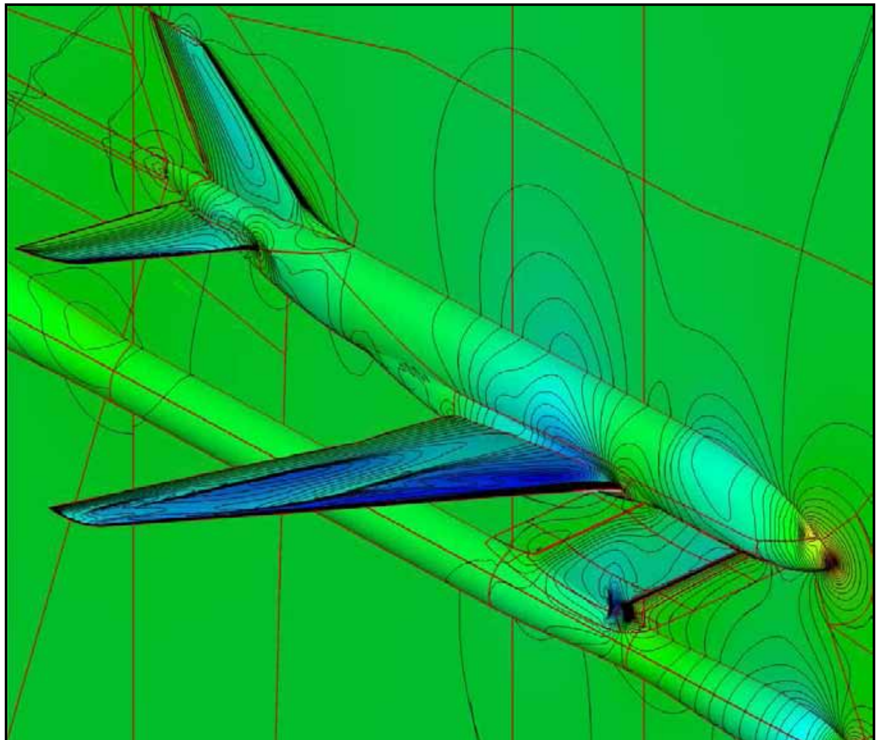
FLIRET (2005-2008) *Flight Reynolds Number Testing*

- 6th Framework Programme, 4.6 mEUR, 17 academic and industrial partners (coordination: Airbus D, partners: Airbus-F, -UK, -E, Dassault, DLR, ONERA, IMPPAN…)

- **IMP PAN**: ST 1.2.1 Blade-sting detailed aerodynamic design and interference assessment (direct cooperation with Airbus-E and ONERA)



REMFI model with a blade sting support – grid details



REMFI model with a blade sting support - pressure map

Coordination of EC project

Unsteady effects of shock induced separation

Objectives of UFAST:

*The **first objective*** of the UFAST project is to provide a comprehensive **experimental data base**

Experiments of "basic"interaction (WP-2)

and with flow "control devices" (WP-3) e.g. perforated walls, sublayer vortex generators, stream-wise vortex generators, synthetic jets, electro-hydrodynamic actuators EHD/MHD

*The **second objective*** - application of recent developments in numerical simulations:

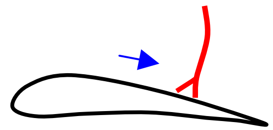
RANS/URANS (WP-4),

***hybrid RANS-LES and LES (WP-5)*.**

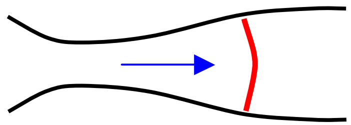
"best-practice guidelines"

*The **third objective***, **improvement in physical understanding** of unsteady effects in shock induced separation

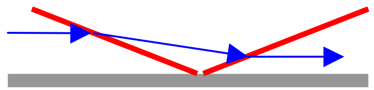
Interaction types considered in UFAST:



Transonic interaction



Nozzle flow



Oblique shock reflection

Częstochowa University of Technology

Institute of Thermal Machinery

Areas of interest **- Aircraft aerodynamics**

Expertise:

- ***Modelling of flows external aerodynamics especially for high lift configurations (RANS, LES)***
- ***Modelling of flows in blade system of rotating machinery***
- ***Modelling of free flows, jets and wakes in aeronautical industry***
- ***Improvement of models based on a deeper understanding of the physics based on the most advanced experiments***
- ***Experimental investigations of transitional and turbulent flows***

FarWake *(6th FP) – interaction of vortices with airplane for* ***Airbus***

FAR-Wake

FundamentAl Research on Aircraft Wake Phenomena

Coordinator: Thomas Leweke

Centre National de la Recherche Scientifique

Institut de Recherche sur les Phénomènes Hors Equilibre

Marseille, France

Thomas.Leweke@irphe.univ-mrs.fr

+33-4-96139709 (Fax)

Objectives

1. **Gain new knowledge on vortex phenomena, critical in the context of wake turbulence behind civil aircraft, but not sufficiently addressed or understood in previous studies**
2. **In support of new experimental an numerical investigations, heoretical/analytical treatment is applied to obtain a systematic description and understanding of the wake phenomena**

Contribution of the Institute of Thermal Machinery

Hot engine jets/compressibility effects; LES and experiment on stability of hot jet

The main aim of the subtask is systematic numerical wuth use of Large-Eddy Simulation method and expeimental studies of the structure and stability of hot jet

WallTurb *(6th FP) – basic research on turbulent boundary layer affected by adverse pressure gradient for **Airbus***

PROJECT COORDINATOR: Michel Stanislas,
Laboratoire de Mecanique de Lille, France

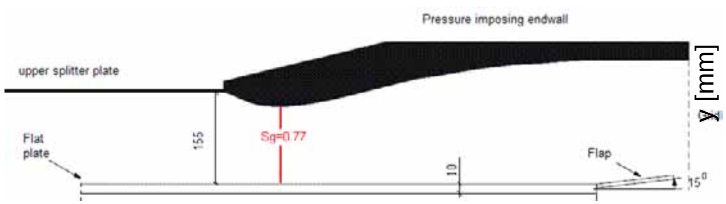
Problem: Flow under adverse pressure gradient and flow close to separation

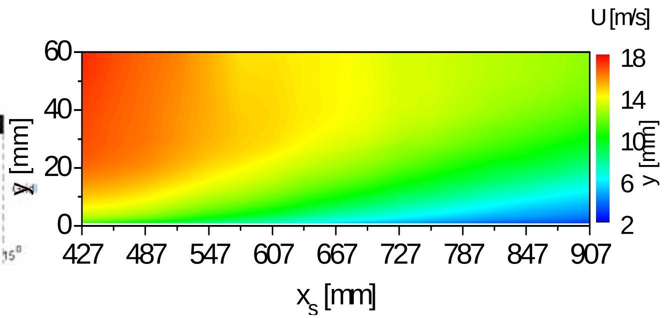
Aimes:

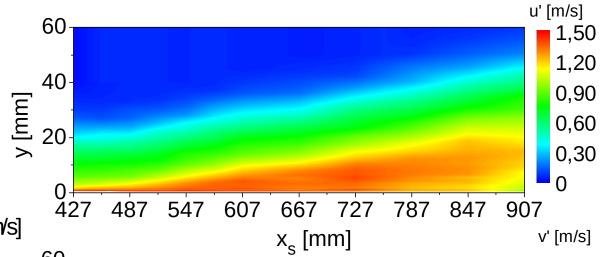
- **better understanding and modelling of physics in near wall region, especially under Adverse Pressure Gradient (APG) and close to separation !!!**
- **improved near wall modelling with RANS methodology**
- **development other near wall models (LES, DES, LODS)**

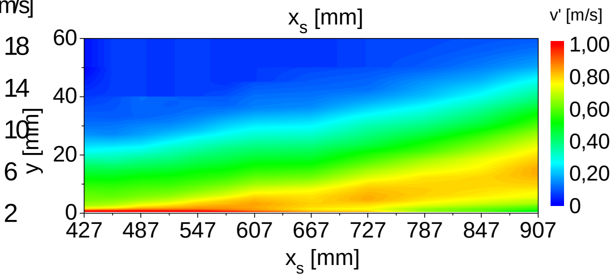
Contribution of the Institute of Thermal Machinery

WP2: Experimental investigation of turbulent boundary layer structure under the influence of Adverse Pressure Gradient (APG) in the condition similar to be present in the turbomachinery flow: -flat plate experiment with APG section

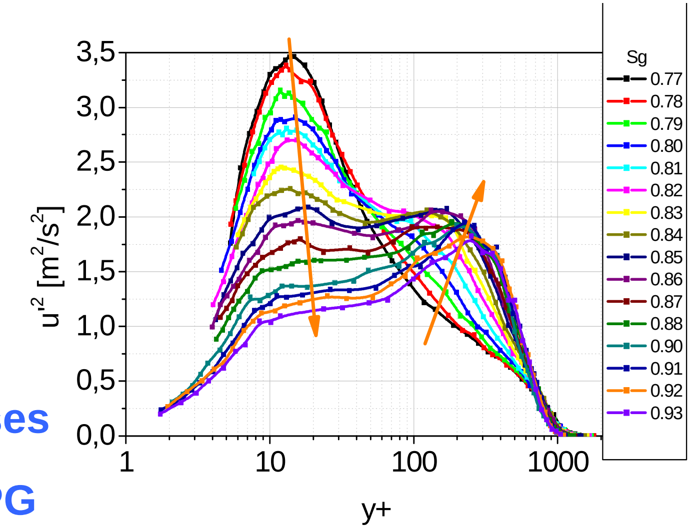








WP2: Experimental investigation



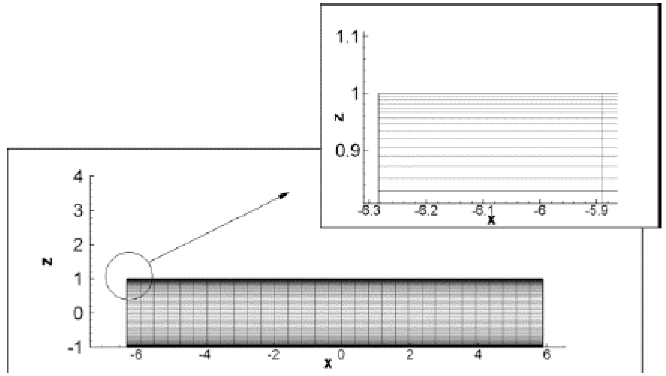
Reynolds stresses

WP 5: LES calculation of channel flow for ZPG and APG

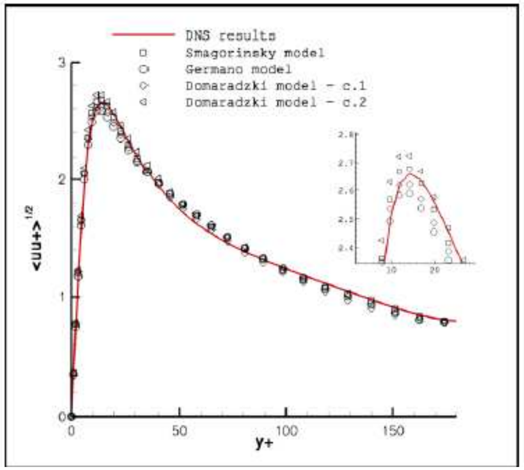
• application and verification of Dynamic Smagorinsky, WALE and estimation type model (Domaradzki and Saiki) for near wall modelling

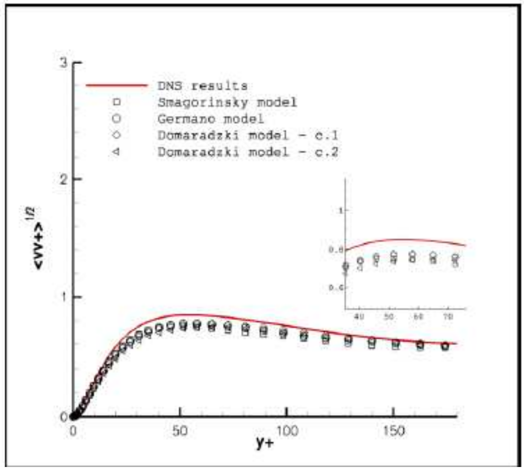
Calculations for Re_τ=180 and 550 [Torroja database]

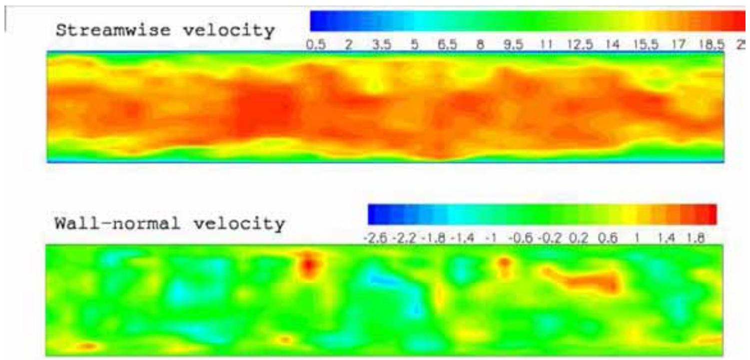
Comparison of: Smagorinsky, Germano, Domaradzki subgrid models



Reynolds stresses





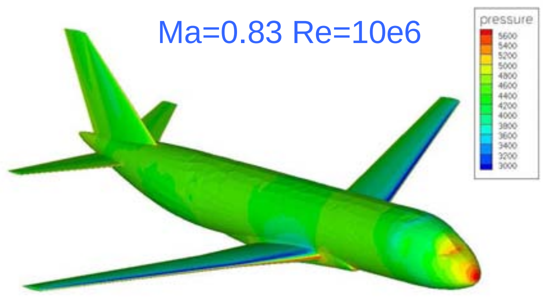


POZNAN UNIVERSITY of TECHOLOGY

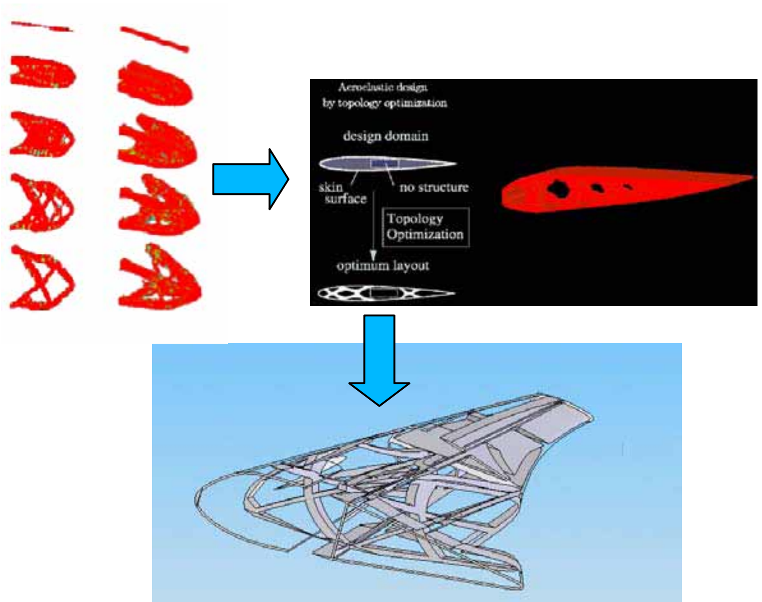
POLITECHNIKA POZNAŃSKA

Virtual Engineering Group

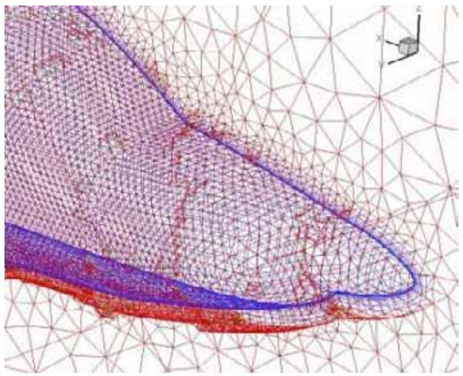
CFD & Structure Optimization



Competence: CFD
Topological Optimization



Optimal wing structure

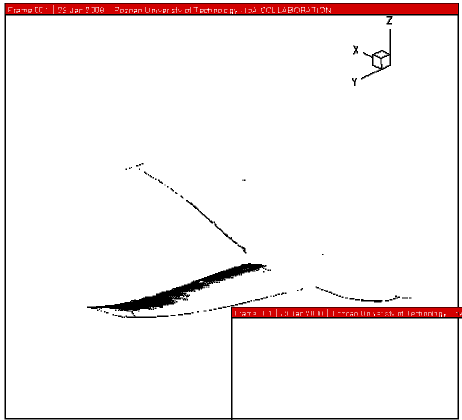


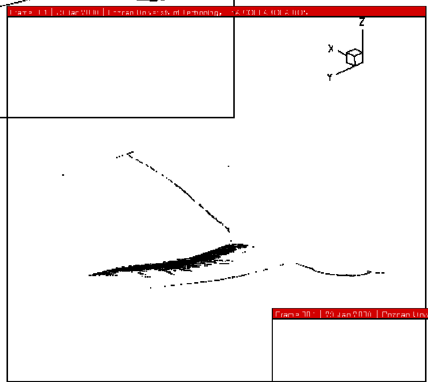
CFD – grid for
RANS and URANS computations
(viscid layer)

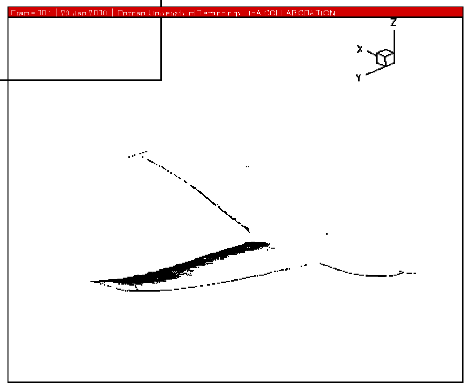
EU Project: (in preparation)
EMORPH

Electroactive MORPHing

Full scale aeroelastic simulations



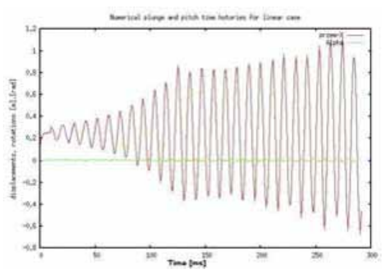




Competence: CFD + CSM coupling
Nonlinear analysis

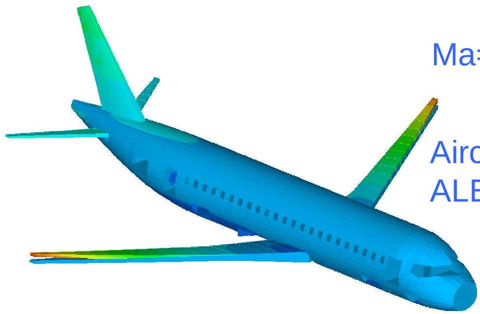
EU Project TAURUS

Technology Development for Aeroelastic Simulations
on Unstructured Grids



Aircraft input data:
Institute of Aviation Warsaw

Flutter analysis



Ma=0.83 Re=10e6

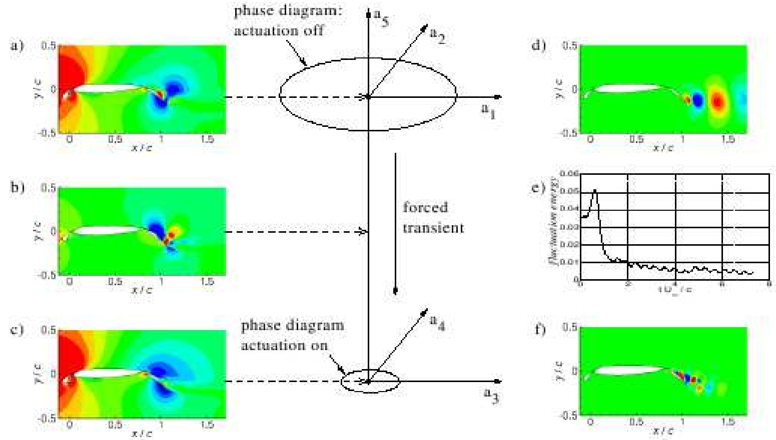
Aircraft input data:
ALENIA Italy

Aeroelasticity

Low Dimensional Analysis and Active Flow Control

Competence: LDA in Aeroelasticity
LDA in Flow Control

$$v^{[N]} = \sum_{i=-1}^{N} a_i(t)\, v_i(x)$$



Feedback Flow Control
(AIAA 2007-1313)

Projects:

Deutsche Forschungsgemeinschaft (DFG) grants NO 258/1-1 and NO 258/2-3,
US National Science Foundation (NSF) grants 0524070 and 0410246,
US Air Force Office (AFOSR) grants FA95500510399, FA95500610373.
Collaborative Research Center (Sfb 557) "Control of complex turbulent flow" by the DFG

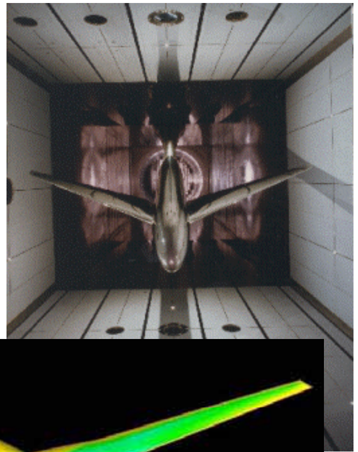
Warsaw University of Technology

Politechnika Warszawska

Department of Aerodynamics (Jacek Rokicki)
Department of Aircraft Design (Zdobysław Goraj)

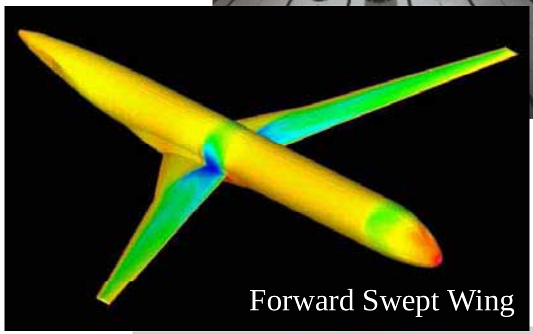
Computational Fluid Dynamics Group

In-house codes



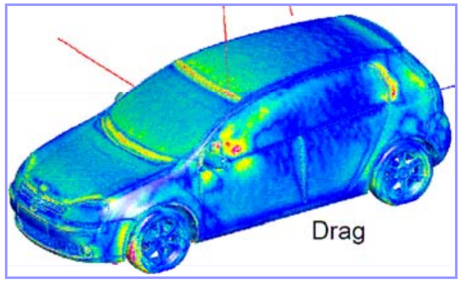
HiReTT
1999-2003

ADIGMA
2006-2009


Forward Swept Wing

M-DAW

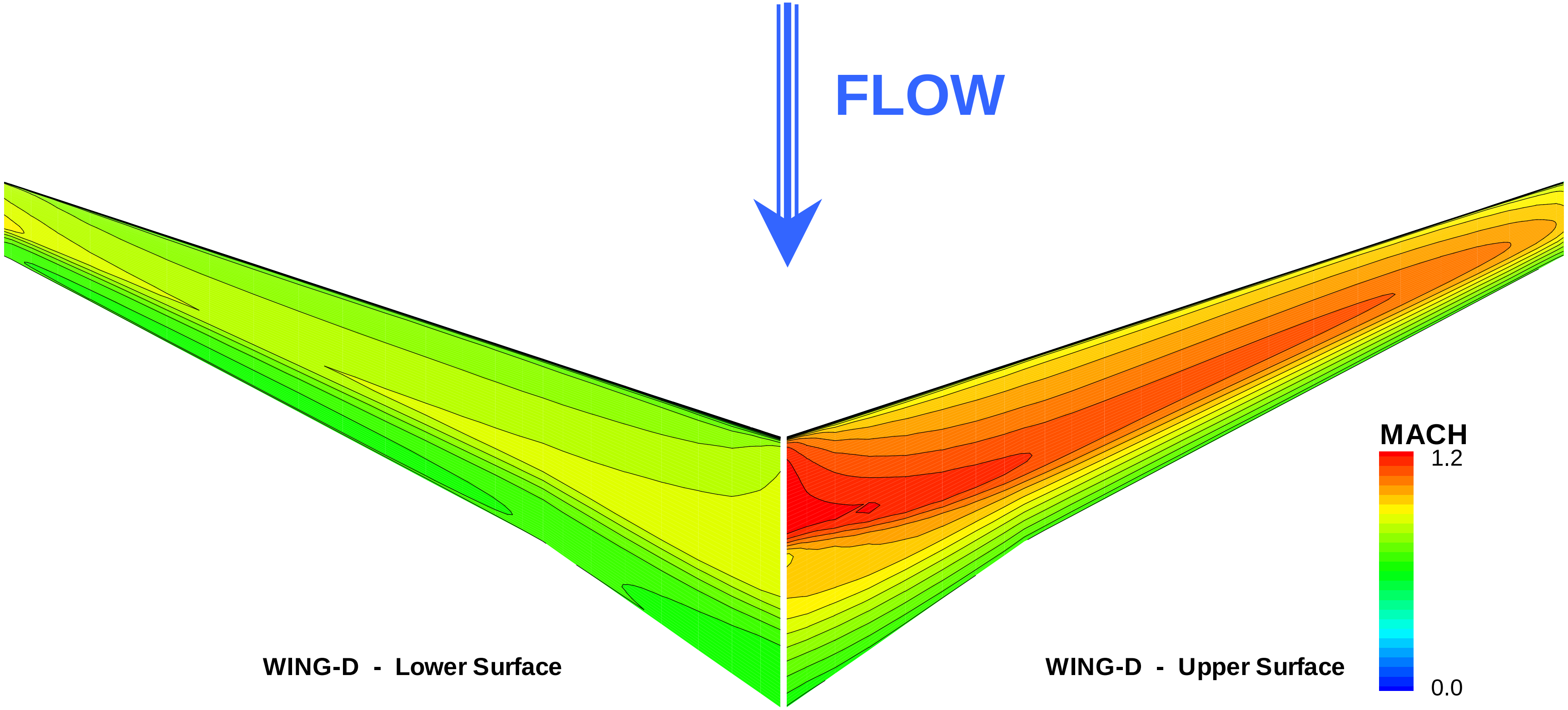
NACRE
2005-2009



FLOWHEAD

2008-2011
Fluid **O**ptimisation **W**orkflows for
Highly **E**ffective **A**utomotive **D**evelopment Processes

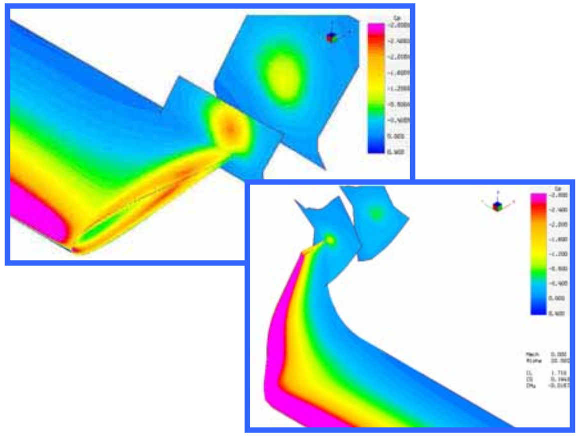
NACRE – Laminar FWS Optimisation

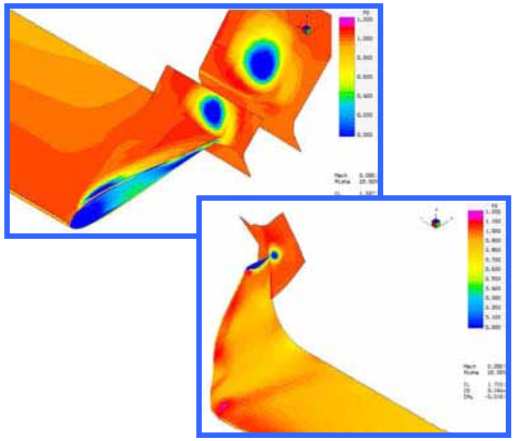


15 DC reduction possible via laminarisation
(Design WUT + DLR)

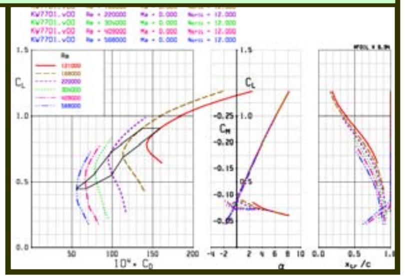
Aerodynamic design group (K.Kubryński)

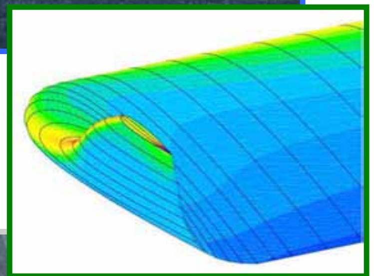
WING AERODYNAMICS



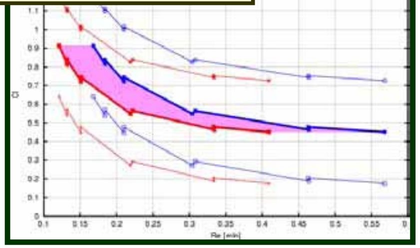


OPTIMIZED AIRFOIL FOR WING STATION



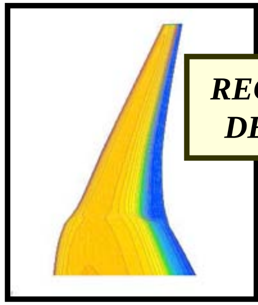


REQUIREMENTS FOR WING SECTION

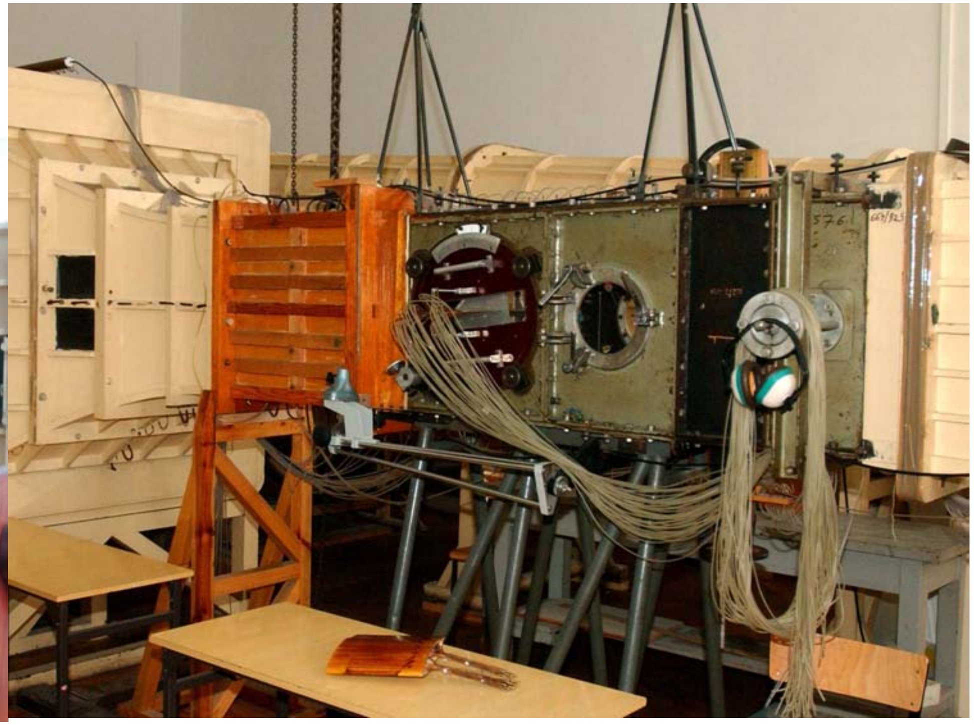


INITIAL

→ 3D - DESIGN PROCESS →



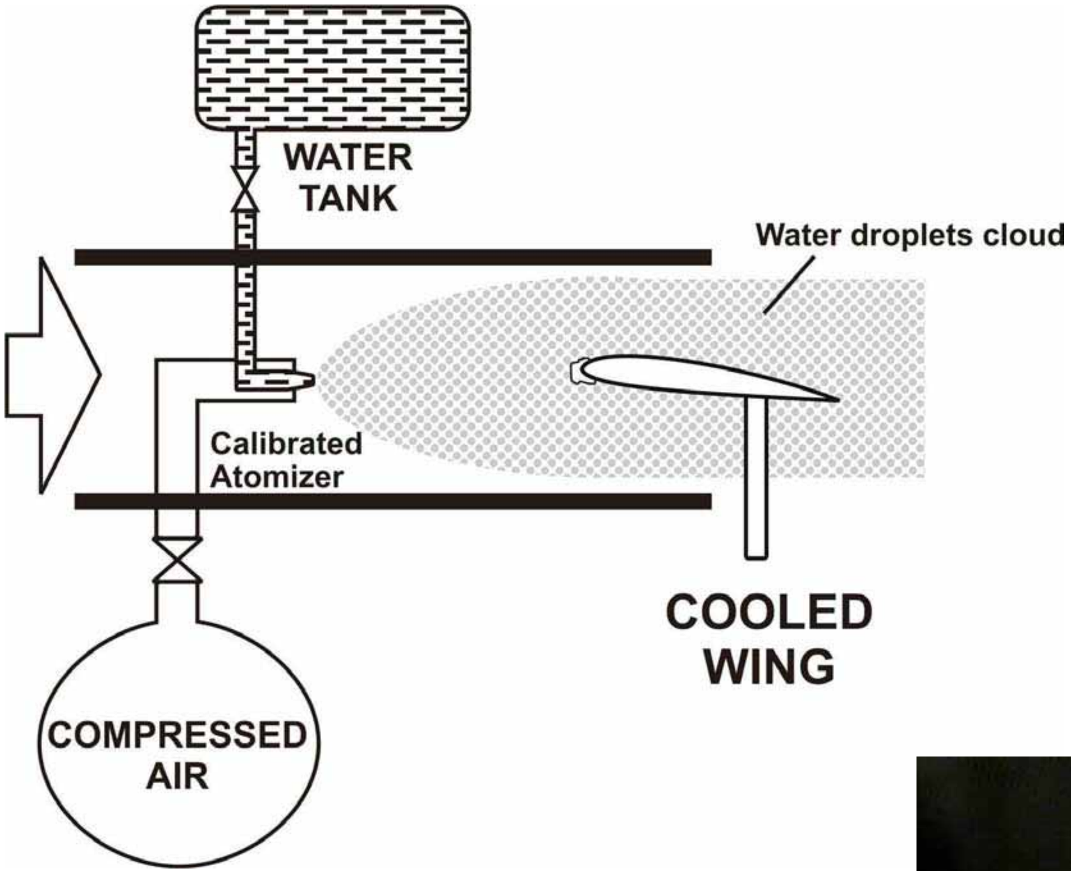
REQUIRED = DESIGNED

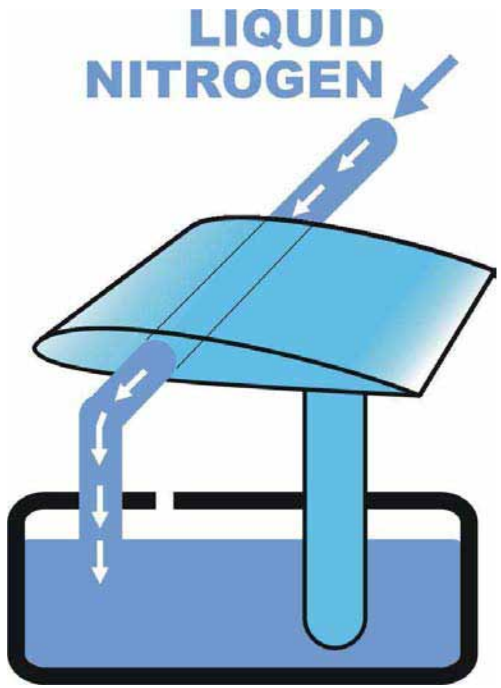


Experimental facilities

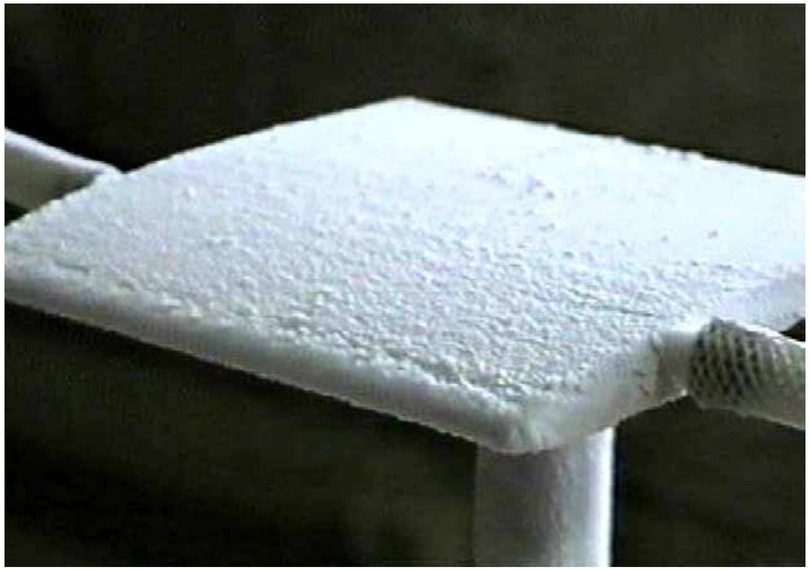
Range of wind-tunnels:

- Laminar
- Transonic
- Low Speed





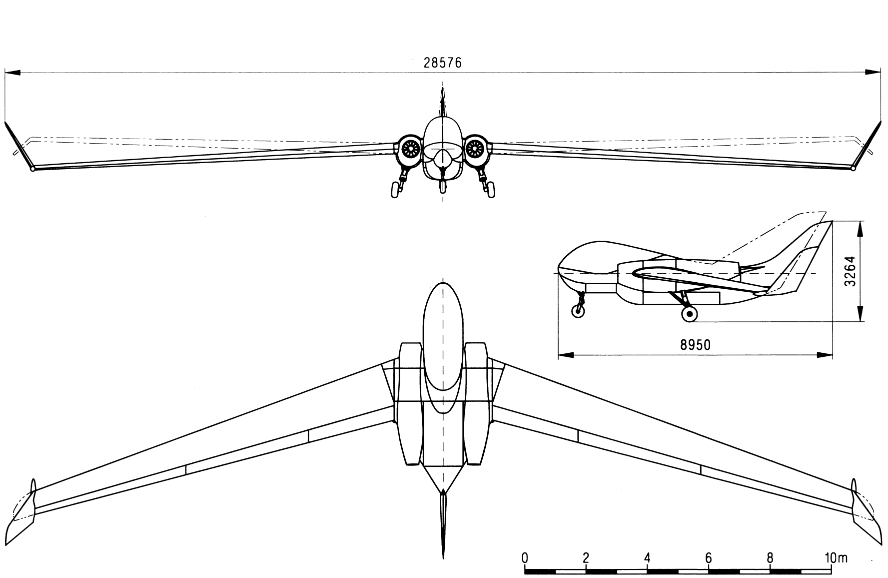
Simulation of Ice Accretion



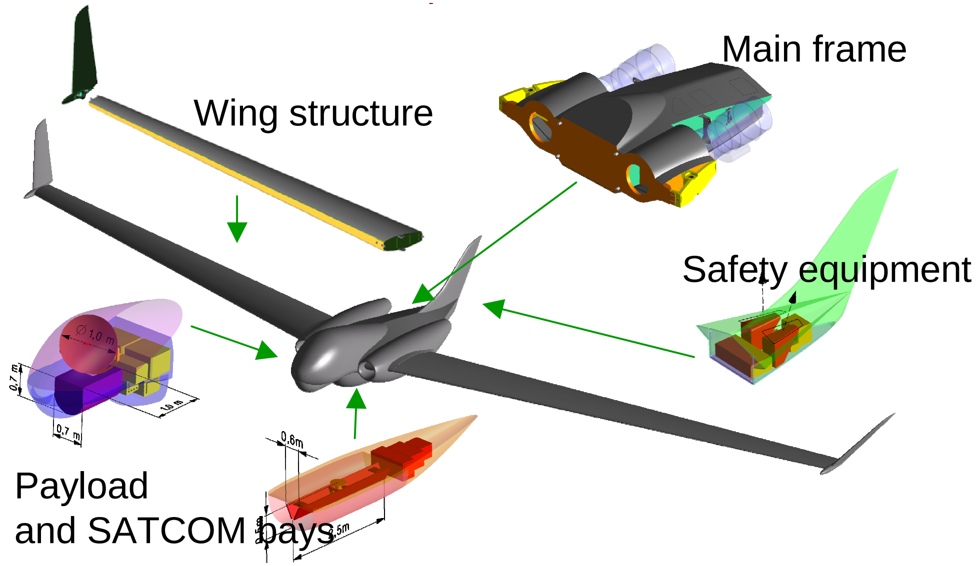
Warsaw University of Technology

Department of Aircraft Design (Zdobysław Goraj)

WUT – PW-114 HALE UAV Configuration

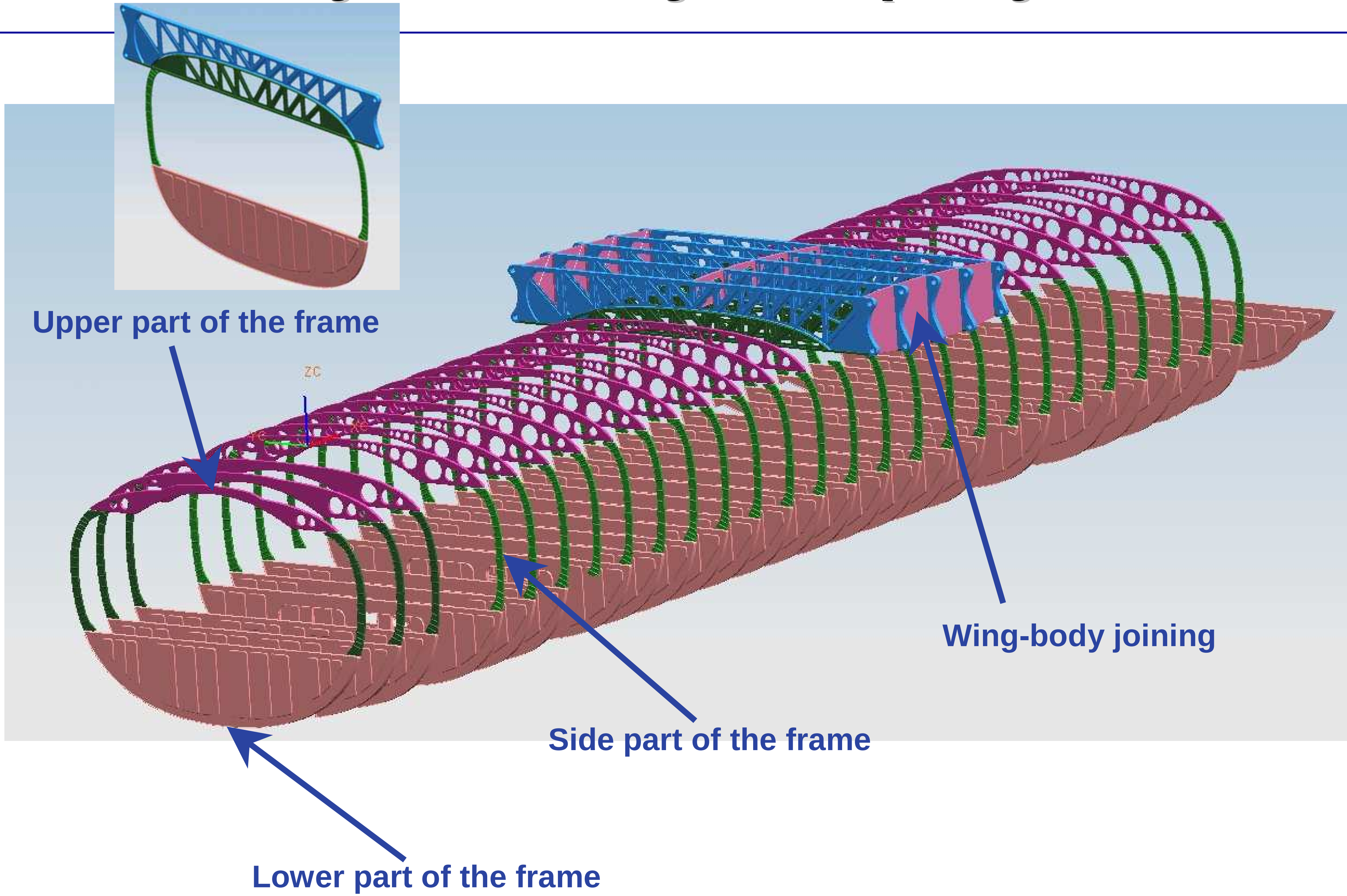


Blended Wing HALE – Geometry

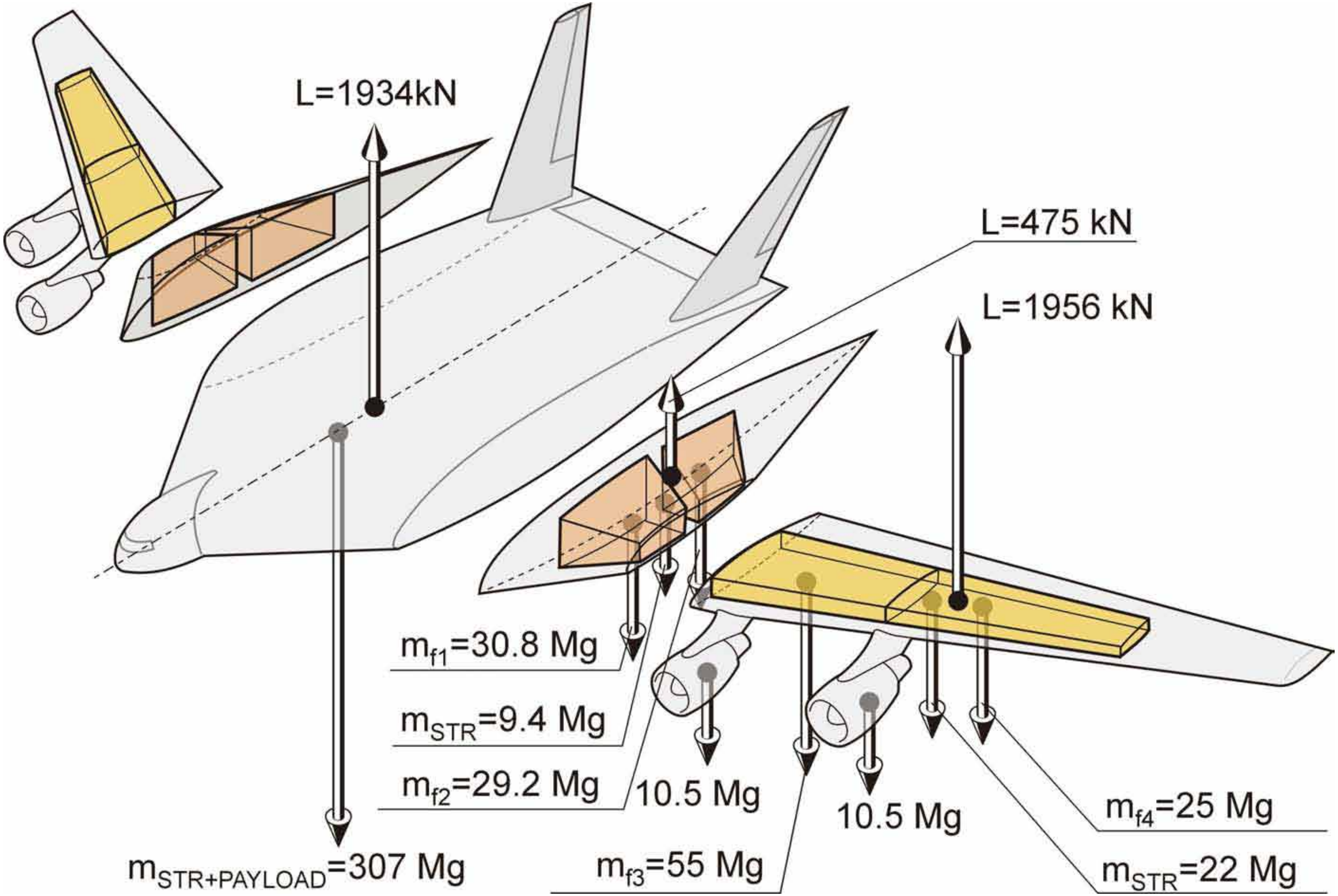


Maximum Takeoff Weight	4350 kg	Propulsion Type	***Jet***
Basic Empty Weight	1500 kg	Propulsion	2 X FJ44-3
Fuel Weight	2350 kg	Flight Altitude	***60*** kft
Payload Weight	***500*** kg	Total Endurance	***25*** hr
Span	28 m		
Reference Area	44.38 m^2		

NACRE – fuselage structure for high comfort passenger cabin



NACRE – Fuel tanks optimisation



CONCLUSIONS

- **Flight physics is traditionally an active area of research in Poland (successful within European as well as national projects)**
- **Cooperation with Polish industry is still unsatisfactory**
- **Further investment is needed in experimental and computational/software infrastructure**
- **Clear guidance needed for PL priorities in Research**

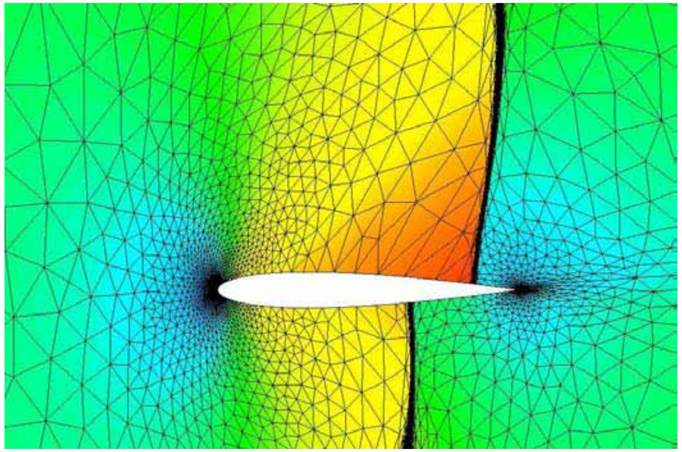
IMPORTANT NEW INITIATIVES

- **AEROPLAN - Dedicated super-computing center for aeronautic applications (IMP+TASK+...)**
- **National CFD software for Aeronautics (PW+PCz+ILOT+PP+IMP+...)**
- **LAPT - Cold Flow Turbine Test Facility (AVIO+PW+WZL4+WAT)**

ACARE's AGENDA

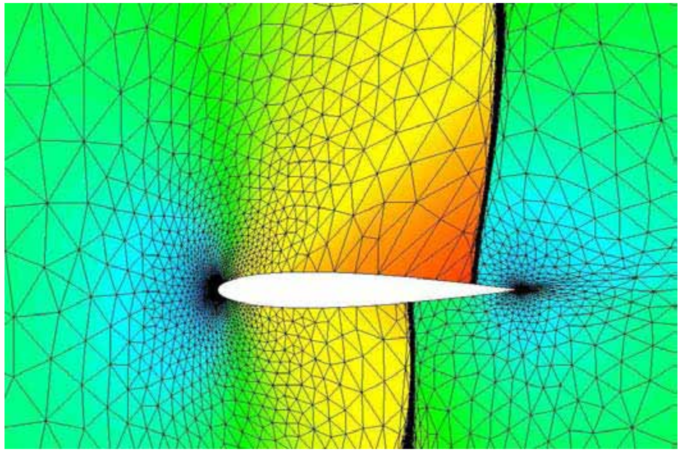
- Greening of Air Transport
- Increasing Time Efficiency
- Ensuring Customer Satisfaction and Safety
- Improving Cost Efficiency
- Protection of Aircraft and Passangers
- Pioneering the Air Transport of the Future

Relevant to Flight Physics



ACARE's AGENDA

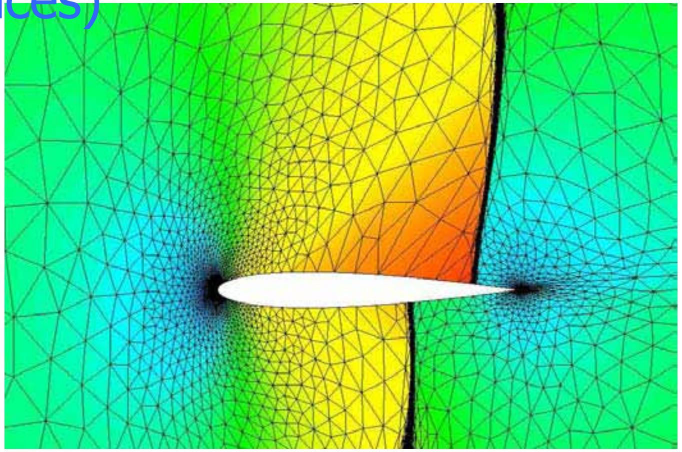
- Greening of Air Transport
  - Reduce fuel consumption + CO2 emissions
  - Reduce Nox emissions by (landing and take-off)
  - Reduce unburnt hydrocarbons and CO emissions
  - Reduce external noise
- Increasing Time Efficiency
- Ensuring Customer Satisfaction and Safety
- Improving Cost Efficiency
- Protection of Aircraft and Passangers
- Pioneering the Air Transport of the Future



Flight Fhysics contribution

Drivers of progress in FF:

- Improved Simulation Tools
- New Design/Optimsation Tools
- Better modelling (turbulence, transition, ...)
- More reliable, high quality experiments
- New ideas for flow control
- New design concepts/ideas
- Cross fertilisation with other branches of science (e.g. Material sciences – micro/nano sciences)



THANK YOU